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The Journal of Philosophy
Psychology and Scientific Methods

RELATIVITY

THERE are two important questions to relativity: first, a physical question, "Do the laws of relativity hold true in the physical world?" and second, a mathematical question, "What are the laws of relativity?" The first of these will have to be decided by physical experiment, for at present it has not been decided nor is it likely to be for some time to come. The second was recently asked and answered by the Swiss scientist, Einstein,[1] without fear, though not without reproach.

Of the two questions the former is somewhat easier to discuss, and many a man is willing to discuss it with comparative indifference to the latter question. But it is the latter question which will concern us at present because a commentary on Einstein may be welcomed by some readers who like to know what things mean before deciding whether they are true, and because a study of relativity throws light on certain mathematical processes which are often obscured.

Mathematics may be defined as the science of arranging statements in consistent systems. For the sake of this consistency it is necessary that a mathematician should state as clearly as possible what his assumptions are. Then he must follow his assumptions to their logical conclusions, no matter where they may lead. But the mathematician is not a fatalist, and his procedure has the element of safety that if he does not like the conclusions, he is at liberty to change the assumptions.

His procedure is at the same time humble and arbitrary. It is humble because he calls an assumption an assumption, and arbitrary because he reserves the right to say to his reader, "Let us suppose that so-and-so is true"—although his reader may not wish to suppose that so-and-so is true at all, and, in fact, may be violently opposed to the assumption.

The most startling assumption of relativity is that the observed velocity of light is always constant, independent of the motion of the observer and the source of light. That is, light moves just as

[1] *Annalen der Physik*, 1905, p. 891.

fast with respect to us, no matter whether we are moving toward its source or away from it, and no matter how fast we move. There is a single proviso that we should move, as indeed we are accustomed to move, with a velocity less than that of light. In order to bring out the meaning of this physical assumption, let us first propose a mathematical problem, How would a man alter the present ways of measuring time and space if he decided arbitrarily to record the velocity of light as constant, independent of the motion of the observer? A study of this problem throws light not only on the assumptions of physics, but also on the processes of mathematics, for the question involves the larger question, What does it mean to solve an equation?

In early school life solving an equation means either finding an answer in the back of a book or satisfying an instructor that one has gone through a certain mechanical process whose logic, by the way, is apt to be questionable. If we solve an equation for x from this point of view we are supposed to be finding "the value of x." But there is no such thing as *the* value of x, since x may have any value. What we are really doing is finding, if possible, a value of x which will satisfy certain conditions. If the equation is $x-5=0$, we go about its solution properly as follows: "Perhaps there is a value of x which, minus 5, is equal to 0, and if so, let us find it." Many students of mathematics do not understand that this is what it means to solve an equation, insomuch that the poet and story-teller, Edgar Allen Poe, is thoroughly annoyed and writes in his Purloined Letter "I never yet encountered the mere mathematician . . . who did not clandestinely hold it as a point of his faith that x^2+px was absolutely and unconditionally equal to q. Say to one of these gentlemen by way of experiment, if you please, that you believe occasions occur when x^2+px is not altogether equal to q, and having made him understand what you mean, get out of his reach as speedily as convenient, for beyond doubt he will endeavor to knock you down."

The "mere mathematician" described by Poe is evidently unqualified to express the laws of relativity, but the matter may safely be entrusted to three characters, *A*, *B*, and *C* that Stephen Leacock introduces to us in his *Literary Lapses* as follows:

"The student of arithmetic who has mastered the first four rules of his art, and successfully striven with money sums and fractions, finds himself confronted by an unbroken expanse of questions known as problems. These are short stories of adventure and industry with the end omitted, and, though betraying a strong family resemblance, are not without a certain element of romance.

"The characters in the plot of a problem are three people called *A*, *B*, and *C*. The form of the question is generally of this sort:

'*A*, *B*, and *C* do a certain piece of work. *A* can do as much work in one hour as *B* in two, or *C* in four. Find how long they work at it.'

"Or thus:

"'*A*, *B*, and *C* are employed to dig a ditch. *A* can dig as much in one hour as *B* can dig in two, and *B* can dig twice as fast as *C*. Find how long, etc., etc.'

"Or after this wise:

"'*A* lays a wager that he can walk faster than *B* or *C*. *A* can walk half as fast again as *B*, and *C* is only an indifferent walker. Find how far, and so forth.'

"The occupations of *A*, *B*, and *C* are many and varied. In the older arithmetics they contented themselves with doing 'a certain piece of work.' This statement of the case, however, was found too sly and mysterious, or possibly lacking in romantic charm. It became the fashion to define the job more clearly and to set them at walking-matches, ditch-digging, regattas, and piling cordwood. At times, they became commercial and entered into partnership, having with their old mystery a 'certain' capital. Above all they revel in motion. When they tire of walking-matches—*A* rides on horseback, or borrows a bicycle and competes with his weaker-minded associates on foot. Now they race on locomotives; now they row; or again they become historical and engage stage-coaches; or at times they are aquatic and swim. If their occupation is actual work they prefer to pump water into cisterns, two of which leak through holes in the bottom and one of which is watertight. *A*, of course, has the good one; he also takes the bicycle, and the best locomotive, and the right of swimming with the current. Whatever they do they put money on it, being all three sports. *A* always wins.

"Now to one who has followed the history of these men through countless pages of problems, watched them in their leisure hours dallying with cordwood, and seen their panting sides heave in the full frenzy of filling a cistern with a leak in it, they become something more than mere symbols. They appear as creatures of flesh and blood, living men with their own passions, ambitions, and aspirations like the rest of us. Let us view them in turn. *A* is a full-blooded blustering fellow, of energetic temperament, hot-headed and strong-willed. It is he who proposes everything, challenges *B* to work, makes the bets, and bends the others to his will. He is a man of great physical strength and phenomenal endurance. He has been known to walk forty-eight hours at a stretch, and to pump ninety-six. His life is arduous and full of peril. A mistake in the working of a sum may keep him digging a fortnight without sleep. A repeating decimal in the answer might kill him.

"B is a quiet, easy-going fellow, afraid of A and bullied by him, but very gentle and brotherly to little C, the weakling. He is quite in A's power, having lost all his money in bets.

"Poor C is an undersized, frail man, with a plaintive face. Constant walking, digging, and pumping have broken his health and ruined his nervous system. His joyless life has driven him to drink and smoke more than is good for him, and his hand often shakes as he digs ditches. He has not the strength to work as the others can, in fact, as Hamlin Smith has said, 'A can do more work in one hour than C in four.'"

This arbitrary and headstrong A is just the man for our purpose. He is obsessed by the idea that the velocity of light is constant and he means to have it so regarded by his associates, B and C. In order to accustom B and C to his methods, A makes a few preliminary experiments in setting and regulating watches. For his first experiment A wishes to have B's watch always an hour behind C's, expressing standard time according to C's watch by values of a variable t and time according to B's watch by values of a variable τ. For his first experiment A establishes the relation between τ and t,

$$\tau = t - 1,$$

where τ is evidently a *function* of t; for a given value of t there is fixed by the equation a definite value of τ. As another experiment A wishes to have B's watch running only five-sixths as fast as C's (quite regardless of the inconvenience to B) and regulates B's watch so that B's time τ is again a function of C's time t,

$$\tau = 5/6\ t.$$

Now A is prepared to regulate his own watch and B's in another arbitrary way so that they will record the velocity of light as constant, independent of the observer's motion. A, B and C are disposed as follows: C is at rest; and A and B are in motion along the straight line CX with a constant velocity v. C's time, as before, is standard time and is represented by t; A's time and B's will be represented by τ. As A and B passed by C in their motion, each took care that his watch should agree with C's watch.

The problem in A's mind is to compare the time that it takes to flash a ray of light from A to B with the time that it takes to flash the ray back again from B to A. C argues that it evidently takes longer for the ray to pass from A to B than from B to A because B is moving away from the flash with velocity v, while A is coming up to meet it with the same velocity. But A says "I want that ray of

light to measure the *same time* both from A to B and from B to A, and if C's way of measuring time and space won't show such a result, I am going to devise a system of my own that will."

What A wants is to express his own time and B's by a function τ so that

$$\tau_1 - \tau_0 = \tau_2 - \tau_1, \tag{1}$$

where τ_0 is the time by A's watch when A sends the flash, τ_1 is the time by B's watch when B receives the flash and sends it back, and τ_2 is the time when A receives it again. The disturbing factor in the problem is the common velocity v of both A and B, therefore we may expect τ to be a function of v. And so it turns out;[2] τ is found to be a function of v and also of t, the time by C's watch since B and A left C, respectively. In terms of v and t the function τ is expressed by the equation

$$\tau = \frac{1}{\beta} \cdot t\,;\ \beta > 1 \tag{2}$$

where $1/\beta$ is a function of v which is less than 1 and becomes smaller as v increases, approaching zero as v approaches the velocity of light. In other words, the faster A and B go the slower their watches must go.

Then from C's point of view no two of the three watches are together. If C's watch and B's watch were together, say, at twelve o'clock, when B left C, at a given time t, say half past two by C's watch, B's watch is behind C's in the ratio 1 to β and is regulated so as to get behind more and more in amount, but always in the same ratio. The like is true of A's watch, but inasmuch as B passed C before A did, B's watch, while regulated like A's watch, has been losing time longer, and so from C's point of view is behind A's watch. If B were to make his watch agree with A's (from C's point of view) he would have to set it ahead, but would not need to regulate it. If either A or B were to make his watch agree with C's (from C's point of view) he would have to set it ahead and regulate it to run faster.

But A is not satisfied with his first achievement recording the velocity of light as constant for both A and B when the light is flashed along the line CX. He wants to make further changes in his system of measurement so that the number which records the velocity of light shall be the same for C as well as for A and B and shall be the same whether the light is flashed along CX or perpendicular to CX or in any other direction. To solve this problem A must change his unit of length as well as his unit of time and alter his foot-rule as well as his watch.[3] He has to make his foot-rule shorter then C's

[2] Supplement, p. 35.

[3] Supplement, p. 40.

when measuring in the direction of his motion CX, but when measuring at right angles to his motion, he may use the same foot-rule that C uses. This means that A has no longer a fixed unit for length independent of direction. He has one unit of length for one direction and another for another, but he records the velocity of light as constant and cheerfully puts up with all the attendant inconveniences.

So far we have regarded the question of relativity as a mathematical question, and the laws of relativity as those equations which would have to hold if the velocity of light is to be recorded as constant, assuming the laws of the "old" physics. And so far there can be no question whatever of the validity of our results. If the "old" assumptions hold true for the physical world, it would be quite possible for an observer to set and regulate his watch and shorten his foot-rule so as to record the velocity of light as constant, that is, as a fixed number of "miles" per "second," where the mile and the second do not have their old meaning if one is in motion, but return to their old meaning if one returns to rest.

But now let us consider the assumption of relativity, which may be stated in this form: The whole material universe shares with A his obsession that the velocity of light is constant under any set of circumstances whatever, and this velocity will be recorded as constant by perfect mechanisms such as watches whether the observers are at rest or in motion. This means that watches in motion regulate themselves and foot-rules adjust themselves to attain the desired end. So when A comes to regulate B's watch and his own, he finds that it is not necessary; the watches have done it for him, and as for shortening his foot-rule, the foot-rule has anticipated him and has obligingly shortened itself. This means, of course, that the constitution of matter is affected by its motion. Is this true? Opinions differ; I suppose no one knows.

If the relativity assumption is true, some surprising things might happen. If it were possible for a man to throw his watch into space with the velocity of light at twelve o'clock and have it return to him when the college clock was striking three, his watch would remain at twelve during its motion, would begin running again as soon as it reached him and would remain three hours behind the college clock until he set it forward. If it were possible for a man to leave the earth and travel through free space at the velocity of light for fifty years and return again to the earth, he would find himself younger than his own children because all his physical processes would have stopped in the meantime by virtue of his velocity.

But although the results of the relativity theory are surprising, they are not absurd because until lately we have never been concerned with velocities approaching in any way the velocity of light.

It is quite possible that electrons may move in accordance with the theory. At any rate, modern physicists are convinced that electrons do not move according to the classical laws of physics. Physicists are still divided into two camps with respect to Einstein's theories. Mathematicians are not divided because mathematics does not ask whether the laws of relativity are true or not, but restricts itself to showing what the laws of relativity are and from what assumptions they are derived.

Supplement

Let the fixed point C be taken as the origin of coordinates for the observer C, and let (standard) time according to C's system be recorded by values of a variable t, and the distance from C of a given point on the moving line AB be recorded by values of the variable x, measured in C's units of length. Let the time according to A's system be given by values of a variable τ, where τ is to be determined as a function of x and the velocity v so that

$$\frac{1}{2}(\tau_0 + \tau_2) = \tau_1, \tag{1}$$

provided τ_0 represents the time of starting from A toward B of a ray of light, τ_1 represents the time when this ray of light is reflected from B back toward A, and τ_2 represents the time when the ray of light reaches A again.

It must be kept in mind that A's problem of finding a function τ such that

$$\frac{1}{2}(\tau_0 + \tau_2) = \tau_1,$$

is a mathematical problem and does not involve any physical assumption whatever.

To determine this function $\tau(x, t)$ A finds it convenient to introduce a new variable x' such that

$$x' \equiv x - vt,$$

where x' as well as x is measured in C's system. Since x' records the distance from the moving point A to a moving point P on AB, x' is evidently independent of the velocity v and also of the time t that the body AB has been in motion, and, therefore,

$$\frac{\partial x'}{\partial t} = 0.$$

From C's point of view the time occupied by the ray in passing from A to B is $\frac{x'}{V - v}$ and the time occupied by the ray in passing from B to A is $\frac{x'}{V + v}$, where V is the velocity of light in C's system and x' is

the coordinate corresponding to the point B. Then the equation (1) above may be written

$$(1') \quad \frac{1}{2}\left[\tau(0, t) + \tau\left(0, \left\{t + \frac{x'}{V - v} + \frac{x'}{V + v}\right\}\right)\right] = \tau\left(x', t + \frac{x'}{V - v}\right).$$

A's problem is to find, if possible, a function of x' and t that will satisfy (1'). Of course, it is possible that there is no such function, but, on the other hand, it is quite possible that such a function exists, and we will at least attack the problem as if it could be solved. Let us make the assumption that τ is a linear function of x' and t, whence, corresponding to a single value for x' and a single value for t there will be a single value for τ, and let us suppose further that the value of τ is zero when both x' and t are zero. This will make τ a linear homogeneous function of x' and t. Perhaps these assumptions will make the problem impossible, but perhaps not. At any rate, if we make these assumptions we may apply Euler's theorem for homogeneous functions, which may be stated for this special case

$$x'\frac{\partial \tau}{\partial x'} + t\frac{\partial \tau}{\partial t} = \tau(x', t).$$

By virtue of this theorem we may replace each one of the terms in (1') by an expression involving the partial derivatives of τ with respect to x' and t. For example, we may replace the expression $\tau(0, t)$ by the expression $t\frac{\partial \tau}{\partial t}$, and similarly we may replace the expression

$$\tau\left(0, \left\{t + \frac{x'}{V - v} + \frac{x'}{V + v}\right\}\right)$$

by the expression

$$\left\{t + \frac{x'}{V - v} + \frac{x'}{V + v}\right\}\frac{\partial \tau}{\partial t}$$

and the expression

$$\tau\left(x', t + \frac{x'}{V - v}\right)$$

by the expression

$$x'\frac{\partial \tau}{\partial x'} + \left(t + \frac{x'}{V - v}\right)\frac{\partial \tau}{\partial t}.$$

Making these substitutions in (1') we have the equation

$$(2) \quad \frac{1}{2}\left(\frac{1}{V - v} + \frac{1}{V + v}\right)\frac{\partial \tau}{\partial t} = \frac{\partial \tau}{\partial x'} + \frac{1}{V - v}\frac{\partial \tau}{\partial t}$$

or

$$(3) \quad \frac{\partial \tau}{\partial x'} + \frac{v}{V^2 - v^2}\frac{\partial \tau}{\partial t} = 0.$$

On the assumption that the function τ is linear and homogeneous, it is easy to find a function which will satisfy (3), namely,

$$\tau = a\left(t - \frac{v}{V^2 - v^2}x'\right), \tag{4}$$

where a is constant with respect to t and x'.

Of course, the proof of this mathematical pudding is in the eating, and the question is now, Have we actually found a function τ that will satisfy (1')? By substitution in (1') this is found to be the case and the problem is completely solved. It makes no difference what value is given to the constant a; any value for a will fulfil the required conditions, so that we are free to choose a to satisfy some other set of conditions.

A goes on to define the distance ξ along the line CX passed over by a ray of light in a given time τ by means of the equation

$$\xi = V\tau, \tag{5}$$

where V is the number which records the velocity of light in C's system. By this means A keeps his own measure of the velocity of light in the direction CX equal to C's measure of the velocity of light, and ξ, which has been defined as a function of τ, is readily fixed as a function of C's length x'. If we substitute for τ its value from (4) we have the equation

$$\xi = aV\left(t - \frac{v}{V^2 - v^2}x'\right) \tag{6}$$

and since $t = \frac{x'}{V - v}$, equation (6) may be written

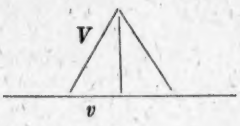
$$\xi = \frac{aV^2}{V^2 - v^2}x'. \tag{7}$$

A now defines the distance η perpendicular to CX, passed over by a ray of light in a given time τ by means of the equation $\eta = V \cdot \tau$ in order to keep the velocity of light equal to V when measured in the η-direction. Substituting for τ its value from (4) and noting that $x' = 0$,

$$\eta = aV \cdot t. \tag{8}$$

The quantity t may be expressed as a function of y as follows: From C's point of view, a ray of light moving perpendicular to the line CX and reflected again so as to meet the observer A seems to have passed over the path of an isosceles triangle whose half base is proportional to v, whose leg is proportional to V, and whose altitude is y, so that the component of the velocity in the y-direction is $\sqrt{V^2 - v^2}$. The

time t is given by the equation



$$\frac{y}{\sqrt{V^2 - v^2}} = t \tag{9}$$

and hence

$$\eta = \frac{aV}{\sqrt{V^2 - v^2}} y. \tag{10}$$

The form of (10) as well as (7) makes it convenient to denote the fraction $\frac{V}{\sqrt{V^2 - v^2}}$ by the symbol β, and to write the undetermined constant a as $\frac{1}{\beta}$ times a quantity $\phi(v)$ which is itself undetermined at present. Then (4), (7) and (10) may be written

$$\tau = \phi(v)\beta\left(t - \frac{v}{V^2}x\right), \tag{11}$$

$$\xi = \phi(v)\beta(x - vt), \tag{12}$$

$$\eta = \phi(v)y. \tag{13}$$

Let us now impose two conditions upon the undetermined function $\phi(v)$; first, that a transformation from C's system to A's, where A is regarded as having a velocity v with respect to C, followed by a transformation from A's system to a system that has a velocity $-v$ with respect to A, shall restore C's system unchanged. This will not interfere with the measurements of the velocity of light and will introduce symmetry into our systems—that is, C's system relative to A will behave as A's system relative to C.

If a transformation is made from C's system to A's, we have the equations (11), (12), and (13). Similarly if a transformation is made from A's system to a system moving away from A with the velocity $-v$, we have for the new system

$$t' = \phi(-v) \cdot \beta(-v) \cdot \left\{\tau + \frac{v}{V^2}\xi\right\}, \tag{14}$$

$$x'^{4} = \phi(-v)\beta(-v)(\xi + v\tau), \tag{15}$$

$$y' = \phi(-v)\eta. \tag{16}$$

Substituting in (14) the values of τ and ξ from (11) and (12) we

[4] This use of x' must not be confused with the foregoing.

find that

$$t' = \phi(-v) \cdot \phi(v) \cdot t,$$

and, therefore, if C's system is to be restored unchanged by this double transformation, the product $\phi(-v) \cdot \phi(v)$ must be equal to 1. This imposes our first condition on the function $\phi(v)$.

Now let us impose on $\phi(v)$ the further condition that A's length η, measured in a direction perpendicular to his motion, shall bear the same relation to C's length y (parallel to η) as the coordinate η' of an observer A' who is moving away from C with A's velocity in the opposite direction. This again will not interfere with measurements of the velocity of light, but will introduce further symmetry into the given systems, since it will make the value of a coordinate perpendicular to the line of motion dependent only on the amount and not on the sense of the motion. If we impose this condition we have the equation

(17) $$\eta = \eta',$$

and since

(18) $$\eta = \phi(v) y,$$

(19) $$\eta' = \phi(-v) y,$$

it follows that

$$\phi(v) = \phi(-v).$$

We have now imposed on the function $\phi(v)$ the two conditions $\phi(v) \cdot \phi(-v) = 1$ and $\phi(v) = \phi(-v)$, both of which are satisfied if we put $\phi(v)$ equal to 1. This value for $\phi(v)$ reduces our former equations (11), (12), and (13) to the following:

(20) $$\tau = \beta\left(t - \frac{v}{V^2}x\right),$$

(21) $$\xi = \beta(x - vt),$$

(22) $$\eta = y,$$

where

$$\beta = \frac{1}{\sqrt{1 - \left(\frac{v}{V}\right)^2}}; \ \beta > 1,$$

and since, for the point A, $x = vt$ and for other points on CX, $x - vt = x'$ these equations may be written

(23) $$\tau = \frac{1}{\beta}t \ ; \ \frac{1}{\beta} < 1,$$

(24) $$\xi = \beta x' \ ; \ \beta > 1,$$

(25) $$\eta = y.$$

This means that A's watch is running slower than C's and that his foot-rule, when measuring along CX is shorter than C's, but when measuring perpendicular to CX is the same as C's.

So far we have made no physical assumption. The physical assumption may be introduced at this point, namely, "The material universe behaves in accordance with the last group of equations."

Suppose now that a given mass m is moving in the direction CX with a given velocity. This velocity, measured by the observer C, is x'/t, and measured by the observer A, is ξ/τ. If we equate the momenta recorded by the two observers[5] we have the equation

$$m_C \cdot \frac{x'}{t} = m_A \cdot \frac{\xi}{\tau}; \quad \xi = \beta x', \quad \tau = \frac{1}{\beta} \cdot t.$$

From this equation we may find the mass from A's point of view in terms of the mass from C's point of view

$$m_A = \frac{1}{\beta^2} \cdot m_C.$$

Suppose that a given mass M is moving perpendicular to CX. Its velocity according to the observer C is y/t, and according to the observer A is η/t. If we equate the momenta recorded by the two observers, we have the relation

$$M_C \cdot \frac{y}{t} = M_A \frac{\eta}{\tau}; \quad \tau = \frac{1}{\beta} \cdot t, \quad \eta = y$$

from which we may find the mass from A's point of view in terms of the mass from C's point of view

$$M_A = \frac{1}{\beta} \cdot M_C.$$

The mass M is called by Einstein the *transverse* mass, the mass m the *longitudinal* mass of a given body. Both masses are functions of β and hence of A's velocity. Therefore, according to the Theory of Relativity, the measures of all three of the fundamental elements of physics, time, length, and mass vary with the velocity of the observer.

CHARLES W. COBB.

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[5] Cf. Bumstead, *Am. Jour. Science*, Vol. 4, No. 26, pp. 498–500.

THE DYNAMIC VALUE OF CONTENT

IN all discussions of the relation between mind and body and of the three main theories (parallelism, interactionism, and double aspect theory) and their variants, it is assumed that we have to deal with *two* series of phenomena, the physical or neural process and the psychic process. This is evident not only in the earlier discussions, but in such later ones as are contained in McDougall's "Body and Mind," Münsterberg's "Psychology, General and Applied," Parmelee's "Science of Human Behavior," etc., not to mention Warren's presidential address on "The Mental and the Physical"[1] and various other contributions. It is obvious that there is *some* connection between mind and body—hence the persistence of the efforts to explain it. The failure of any of the main theories or their variants to find general acceptance is due to the fact that they are either wrong or incomplete.

I do not need to describe the theories or the controversies over them, but will state at the outset that I shall try to show that all three theories are incomplete, since all posit only a *dual* series of phenomena; that there is in reality a *triple* series, *neural* process, *psychic process,* and *psychic* CONTENT; and that there is interaction among them. It is the failure to distinguish between the psychic *process* and the psychic *content,* and the almost universal use of the former when the latter is meant, that has retarded the solution of the problem.

Analysis of a concrete example will best illustrate this contention. Let us see what actually happens and trace somewhat minutely step by step as well as we can the successive events that occur when we examine the pupillary light reflex in a patient.

When light from a match held in front of the eye falls on the retina, movements are set up in the protoplasm of some of the retinal cells, *i. e.,* light-energy is transformed into, or sets free, energy of motion and probably chemical energy. So much we know, for pigment changes its position in the cells, and if the cells are stimulated long enough they undergo observable katabolic changes. Beyond this we can only infer. But reasoning from many facts we can justifiably infer that some activity of these retinal cells acts as a stimulus to the two sets of neurones in the retina with which they are in synaptic relation, the one laterally, the other internally. Doubtless certain of these set into activity (either by transformation or liberation of energy) some of the neurones, still within the retina, with which they are connected, and from which axones extend in through the optic nerve to three groups of cells in and near the optic thalamus.

[1] *Psych. Rev.,* Vol. 21, p. 79.

From one of these groups the stimulation is passed on through two or three successive sets of neurones, the last of which has its endings in the ciliary muscle fibers, and the pupil contracts. This is the light reflex, a pure reflex, unaccompanied by any awareness on the patient's part. It is not a psychological phenomenon, and is not regarded as a manifestation of mind.

At the thalamus certain neurones are stimulated to activity and the patient *senses "light"* (as distinguished from sound or other kind of sensation). This is the first of the psychic reactions.

From about this region the stimulation travels by two other nerve paths. The first leads through certain motor neurones, of which one branch traverses the facial nerve to the eyelids, whereupon the man *winks,* and of which another goes to various muscles, whereupon the man *converges* the axes of *his eyes* upon the point of light, *turns his head* a little, etc. These are reflexes, but the man is aware of them, and may be able to control them. (I will not undertake to trace the paths of neurones involved in the awareness or the control.)

The second nerve path leads to the cuneus in the posterior lobe of the brain, whereupon the man *sees "a light"* (perhaps "a yellow light at the end of a stick"). This is the act of perception, and it seems to be here that the record of percepts is made which are subsequently recalled as memory-images of things seen.

It may be also that from the region of the thalamus, where the man *senses "light,"* stimulation of unknown sets of neurones occurs, whereupon the man *feels "startled,"* and thence the stimulation is transmitted through motor cells in the cord to certain voluntary muscles (the man jumps), and through certain autonomic and sympathetic paths to the heart, blood vessels, and other organs (the heart beats irregularly, the face blanches or flushes a trifle, etc.). But this is aside from the main path which I wish to follow out, and I shall not refer to it again.

From the cuneus connections are made either directly or through the mediation of one or more sets of neurones with all parts of the cerebral cortex. We know little or nothing about the specific functions of most of them. But it seems a justifiable inference that functional activity of some group or other must subserve the purpose of each psychic event. On this supposition I shall continue to detail the patient's reactions.

From the cuneus unknown cortical neurones are stimulated, and the man *apperceives* the "lighted match held before his eye," *recognizes* the physician, and *recalls* a similar experience of a few days before.

From the cuneus and these other cortical neurones other unknown

cell-groups are activated and he *feels* "annoyed" at the light and at the physician for holding the lighted match before his eye.

From the cell-groups which subserve his feeling of annoyance widespread stimulation of other neurones extends in three main directions,—(1) the sympathetic-autonomic system, affecting heart, blood vessels, etc., (involuntary expression of emotion); (2) cortical and other motor centers, resulting in his scowling, etc., (voluntary instinctive expression of emotion); and (3) other cortical areas which subserve his *thinking* "that he won't stand such tricks," and thence to those subserving his *thinking* of "striking the physician, or pushing the match away, or blowing it out."

Some cortical cells doubtless subserve his making a choice among the alternatives, and probably others his determination to carry out the plan decided on. According to the choice made, certain motor neurones are activated and he puts out his hand and pushes away the match.

There are innumerable other physical occurrences which it would only be tedious to describe and which are unnecessary for the argument.

In all these reactions *neural, i. e.*, physical, *process* is obviously necessary. Some mode or modes of energy are at work, transmitted from neurone to neurone or set free in one by the action of the preceding one. Unless this were so, we would have activity arising *de novo*—something coming out of nothing—a state of affairs which we find nowhere else in nature, and which should therefore require indisputable proof to convince us that it exists here. The facts that we can not measure it, or change it to other better known modes, or even detect it, except by its results in behavior, are not such proofs. They only mean that our means of investigation are still too crude. We may look on the nerve-cell as a station for the transformation of one mode of energy into another, as a battery cell is a station for the conversion of chemical energy into electricity. It is a hypothetical energy whose mode we do not know. We can only call it *neural* energy, or energies. Since the neurones in the chain which leads to the reflex contraction of the pupil never subserve sensation as such, we must assume that they are incapable of doing so, *i. e.*, incapable of the mode of activity necessary for it, and hence have a different mode of activity or energy or a different range of vibration- or radiation-rate or whatever mode it may be, from those which subserve sensation, etc.[2]

[2] In this connection it would be interesting to see if a muscle-stimulatory effect could be elicited if the sensory ganglia of the cord should be connected directly with the motor nerves (thus eliminating the motor cell body) and the sensory end organs excited by their appropriate stimuli.

We see from experiments and clinical observation that the neurones which subserve sensation can not, or at least never do, subserve thinking, willing, executing, etc. We must assume then that each set has its own specific wave-rate or wave-length, or whatever may be its mode.

In the pupillary light reflex there is, so far as we know, no other than neural energy till the muscle cells are reached, where the last neurone sets free energy of motion.

But as soon as we begin to have the *psychic* reactions which we saw in the illustrative case, namely, sensing, perceiving, thinking (of different kinds, as recognizing, recalling, planning, choosing, etc.), feeling (*i. e.*, emoting), willing, another order of phenomenon is introduced. These activities are different from the neural processes on which they depend.

That they are *activities*, manifestations of energy, is evident from the fact that they finally result in muscular *movements* which would not have occurred but for them. If the man had not *sensed* the light, if he had not *felt* and *thought* as he did, etc., he would not have *acted* as he did. That we can and do use transitive verbs, either expressly or by implication, in referring to these activities, while in no sense a proof that they *are* activities, indicates that we regard them as such.

That they are not identical with neural process, nor yet with the nerve cells, though conditioned on them both, hardly needs to be stated. Such identification would be equivalent to that of the locomotion of an engine with the movements of its parts and with the engine itself.

That there are not *two aspects of the same thing* is evident when we consider that we can speak of two aspects only when the aspects are of the same order of phenomenon, and these are shown to be different. McDougall[3] has gone into these points quite exhaustively.

But what modes of energy are they? We must answer, as in the case of neural energy, that it is a hypothetical one, whose modes we do not know. To give them a name we may call them *psychical* energies, and subdivided by calling them sensing, thinking, etc., energies.

What are the relations between the neural orders and the psychical orders? Psychical activity is never seen in the higher animals except in connection with nerve-cells and presumably their activity, and this takes the form of discharge of neural energy. Since we seem justified in considering the psychic activities of sensing, thinking, etc., as modes of energy, are we not forced to the conclusion that

[3] *Cf. Body and Mind.*

while part of the neural energy is transmitted to or transformed in other cells, a part is converted into these forms of psychic energy—perhaps as chemical energy in the battery is converted into electric energy, or as motion is converted into electricity in the dynamo, or electricity into light and heat in the light bulb. This is the more probable, as in the conversion of one mode of energy into another, it is almost always into more than *one* other—in the dynamo, for example, there is always friction developing heat, there is sound, and there are currents of air, etc. It is probable, too, that since the neurones which subserve sensing never subserve thinking or willing, for example, there is marked specificity of both neural and psychic energies. We know of nothing that can give rise to psychic energies except neural energies (unless perhaps in the unicellular organisms), *i. e.*, there is no psychic process without neural process. Whether the converse is true, and *specific* neural activity occurs in the cells which subserve mental functions without giving rise to its corresponding psychic activity we do not know, though it is undoubtedly true that *nutritional* (chemical) changes take place in the nerve-cell without giving rise to psychic acts.

Mental activity is not fully described if we stop at neural process and psychic process. It tells us little of the man's acts if we say he sensed, perceived, apperceived, remembered, thought, felt, planned, decided, and acted. We want to know *what* he did in each of these activities.

We can not act without doing *something*. We can not sense or have a sensation, without sensing something, having a sensation of something; we can not think without thinking something. There is no such thing as mere abstract thinking or feeling or acting. We always sense "light" or "sound" or "warm," etc. We always perceive "a light" or "a sound" or "a warm thing." We always think definite thoughts. We always feel "annoyance," "surprise," "anger," etc. These are the *contents* of the various psychic activities or processes.

This content is not the same thing as the process, for to some extent they may be altered independently of each other. For example, in Trotter's and Davies's experiments on cutaneous sensation[4] the stimulus applied to a definite point of skin gave the sensation "warm"; when the temperature was raised above 100 degrees F., the sensation suddenly became "hot," and when raised above 120 degrees F., it became "pain," indistinguishable from that of a needle prick. Here the same neurones and the same psychic process were involved, but with a changing content. On the other hand, in the

[4] *Jour. Physiol.*, Lond., Vol. 38, p. 134.

psycho-motor retardation of manic-depressive psychosis the thinking process as process may be much slowed without alteration of the content as train of thought. This can be demonstrated in the continuous subtraction of 7 from 100, the patient using the same method of subtracting as when he is well and able to do it much more quickly.

Psychic process and psychic content are perfectly distinguishable, but are inseparable. Just as we can not have pure sensation without content, neither can we have any content without a process of which it is the content. This inseparability makes one again question whether we may not be dealing here with two aspects of the same thing. But, as before, we are dealing with phenomena of different orders, and we can not therefore properly speak of them in that relationship to each other.

What then are their relations to each other? McDougall[5] cites the telegram incident—a man receiving a telegram from a friend reading, "Your son is dead" or "Our son is dead"—to show that *meaning* has an effect on behavior. And he says, "Meanings are . . . essential links between sense-impressions and the behavior they evoke" (p. 311). Meaning in his usage is sometimes equivalent to content as I have used it here; sometimes it has a vaguer, larger, more inclusive connotation. But in such places it includes and is equivalent to the content of several processes (affects, trains of thought, complexes). He thus sees a dynamic value in meaning (hence in content), but can not explain it (p. 271), and still sees only *two* orders of phenomena involved in the problem.

My purpose in citing in such detail the reactions of the patient is to bring out clearly not only the neural processes and psychical processes, but the *content* as well, and especially its dynamic value. There it is seen that in each of the reactions ending in pupillary contraction, neural process alone as stimulation of one by the preceding one was sufficient to account for the end result. But from the time of stimulating the cells in the thalamus and the inauguration of psychic *processes* with their inseparable *contents* it is the latter which determine specifically what each of the succeeding reactions shall be. It was not *sensing* as such that determined the winking, the convergence of eye-axes, the turning of the head, but its content *light*. It is true that these are largely automatic and instinctive reactions and might occur in approximately (though not exactly) the same way as the result of any rather sudden intense sensory stimulus of other kinds, as of sound or pain, and it is perhaps possible that at this level sensation as such, regardless of content, may be sufficient to determine these "thoughtless" acts, if I may so call them. It is the

[5] *Body and Mind*, p. 268.

content of the sensation "light" that is the determinant of the percept "a light"—had the content of the sensation been different, the percept would have been different. It is the *content* of the percept that determines the apperception of the "lighted match before his eyes" and the recollection of a previous similar experience. It is the *content* of the thinking or of the sensing (perhaps both) that makes him feel annoyed. It is the *content* of the affect of *annoyance* that makes his heart beat faster, the scowl come on his face, and the thought arise that he won't stand such tricks, etc. If he had felt *amused, i. e.,* if the *content* of his affect had been different, a wholly different train of bodily and mental reactions would have occurred, through a wholly or largely different set of neurones. It is the *content* of his thinking (that he wouldn't stand such tricks; that he would strike the physician or push the match away or blow it out) that led to his choosing the second plan and deciding to carry that out. It was the *content* of the plan and the *content* of the decision that led to his actually pushing the match away. In no case, unless possibly in the automatic instinctive acts, was it the psychic *process* as such that led to the subsequent reactions.

It can also be shown that content determines to some degree the extent or the intensity, or both, of other mental activities and of conduct.

Content thus enters dynamically into the causal series of reactions that lead from sensation to behavior. Since nowhere else in nature do we see energy set free without some antecedent energy to give it a push, as it were, we are driven to the conclusion that psychic content is some mode or modes of energy. Since we find it inseparably associated with psychic process, and since we do not see it giving rise directly to psychic process, we must assume that psychic process gives rise to it; that is, that psychic energy is transformed into or sets free content-energy, probably the former. This content-energy then serves as a director or selective stimulator, or perhaps as a liberator of neural energy. It is perhaps Max Meyer's "ghost" of a few years ago.[6] How this directive function is carried out is a problem for future investigation.

The real relationships that exist among the three sets of phenomena may be shown diagrammatically, after the analogy of McDougall's diagrams illustrating the different psycho-physical theories.

Fig. 1 represents the side view of the succession of events in the case cited. The dark circles represent the neurones and the neural energy subserving the psychic processes. The light circles represent the psychic processes of sensing, perceiving, etc. The squares rep-

[6] This JOURNAL, Vol. 9, p. 365.

resent the psychic contents. The lines represent the direction in which energy is propagated.

Fig. 2 represents the same events in bird's-eye view, as a map or plan. Neurone connections are shown by lines connecting the dark circles. The actual path taken in the case cited is indicated by the

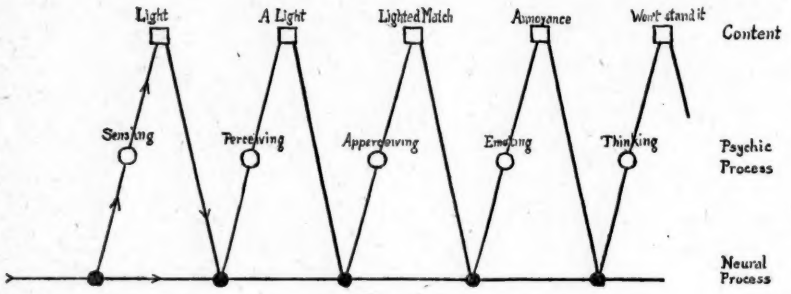

FIG. 1

double lines, of which one connects the neurones, the other represents the selective influence of the content. The possible paths not taken are represented by the square-and-circles from which no lines radiate. Energy is propagated from left to right.

Thus the parallelists are right to the extent that there are parallel

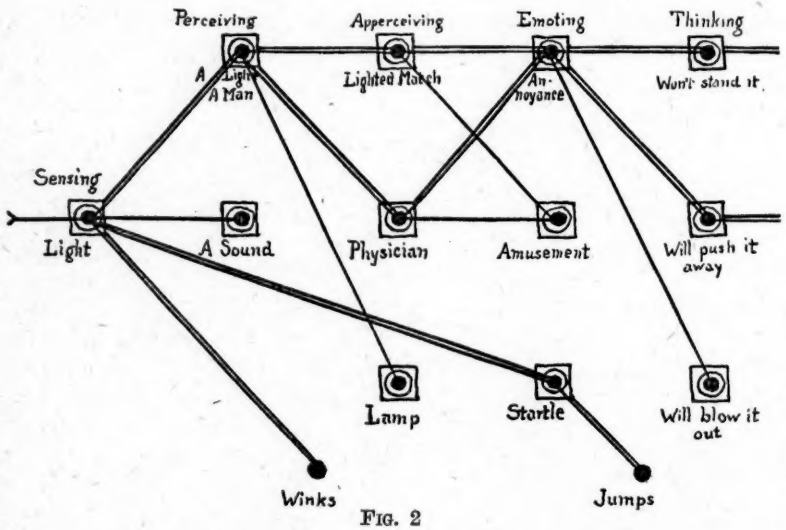

FIG. 2

series of events, and the interactionists are right to the extent that there is interaction between the parallel lines. But both are incomplete in that they fail to recognize that one of their lines, psychic process, is in reality two lines, (1) psychic process in a stricter

sense and (2) psychic content, and that the psycho-physical relationship consists of a triple series, not a dual one. The double aspect theory seems not to have a leg left on which to stand.

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REVIEWS AND ABSTRACTS OF LITERATURE

Fundamental Conceptions of Modern Mathematics—Variables and Quantities. ROBERT P. RICHARDSON and EDWARD H. LANDIS. Chicago and London: The Open Court Company. 1916. Pp. 216.

This is the first instalment of what threatens to be a very large work. The authors have divided that part of their subject which deals with "Algebraic Mathematics" into thirteen parts, of which the present volume is Part One. The important arguments in this book have been published in the *Monist*[1] under the title "Numbers, Variables, and Mr. Russell's Philosophy."

In this review only the logical and philosophical aspects of the book will be considered. Concerning a few of the more technical mathematical discussions in it I do not care to pronounce judgment, though I may mention the fact that when I persuaded a certain eminent mathematician to read it, his condemnation was too severe to be printed.

The authors of a work dealing with the Philosophy of Mathematics might be expected to be thoroughly acquainted with the works of Frege, Schroeder, Peano, Couturat, Poincaré, Whitehead and Russell. Frege has been at least partially read, but without understanding.[2] The only indication that our authors have read Peano or Schroeder is a statement concerning Frege that "as a logician he can not be ranked above the level of Schroeder or Peano."[3] Neither Couturat nor Poincaré is mentioned. Russell's *Principles* of 1903 has been read with partial understanding, but no reference at all is given to the first volume of the *Principia Mathematica* which has been before the public for about six years. One wonders when this work was written.

There are perhaps three points on which it can be commended. In the first place it points out many confusions and examples of carelessness in mathematical definitions, especially concerning num-

[1] July, 1915, Vol. 25, pp. 321–364.
[2] P. 60.
[3] P. 152, note 2.

bers, quantities, and variables. In the second place it rightly insists (in rather strange contrast to the author's avowed Nominalism) on the distinction between symbols and the entities symbolized.[4] The third point concerns a criticism of Russell printed not in this volume, but in the article in the *Monist* to which I referred.[5] Both in the *Principles* and in the *Principia* Russell drew a distinction between the real and the apparent variable (between "any" and "every"). Our authors criticize this, and I think the criticism is correct. I will add that Russell declared in 1914 that the apparent variable is sufficient and that no use need be made of the real variable, but I do not know that he has published this as yet.

The greater part of the volume is concerned with definitions, yet the authors seem absolutely ignorant of modern discussions of definition such as those by Frege and Russell. They assume that for what they call "Realism" all definition is *"per genus et differentiam."*[6] The reader may be sent to the book itself for a discussion of "Realism" ("a doctrine which upholds the existence of things in themselves or substrata underlying our perceptions") and the "Nominalism" which the authors themselves hold.[7]

After saying that number, like other attributes, is based upon resemblances and differences between objects or groups of objects,[8] they hold up their hands in horror at Russell's definition of number.[9] I can not find their own definition. They distinguish between what they call a concrete number (that is, a definite class having a certain number as "attribute") and what they call an abstract number (that is, the number attribute itself). Curiously enough Russell is accused of ignoring this distinction.[10] Then they pass to a discussion of equality and identity.[11] They hold, though for no cogent reasons, that different entities can not have the same attribute, but similar or equal attributes. Doubtless there is some confusion in their minds between "concrete" and "abstract" numbers, but as the question is of some philosophical importance I shall say a word on the problem itself.

Every entity which is known is a "fact," by which I mean all that is symbolized by a complete true proposition. Every "elementary fact" (a fact not involving an apparent variable, a fact which is not "general") contains at least one particular or indi-

[4] Pp. 98–101. *Cf. Monist*, Vol. 25, pp. 337–338, 350.
[5] *Ibid.*, pp. 353, 363–364 (and note 58).
[6] P. 157.
[7] Pp. 155–160.
[8] P. 3.
[9] *Monist, ibid.*, p. 329.
[10] Pp. 4–5. *Monist, ibid.*, pp. 327, 330.
[11] Pp. 5–10. *Monist, ibid.*, pp. 325, 343.

vidual, and at least one universal, either a quality or a relation. Neither a particular nor a universal is ever discovered alone. They are always found only as aspects of some complete fact. Now nearly every one will admit that the same particular or individual can occur in two or more different facts.[12] If the same particular can occur in two different facts, why do we tend to find a difficulty in the theory that the same universal can occur in two different facts? Is it because the particular is usually located by definite spatial relations, while the universal has no spatial relations and belongs with particulars separate in space? This is surely no reason, and I know of no reason except prejudice.

The authors insist that a "variable," in the narrow sense of the term, is neither a symbol, nor one quantity, but is constituted by a set of quantities or numbers which are taken together in order to study their relations.[13] Much abuse is heaped upon Russell for using the name variable in a wider sense. He is accused of being unable to see any difference between the use of x in the proposition "the variable x approaches the limit a" and its use in the proposition "every x is greater than zero."

I regret to have to say that these writers seem incompetent to deal with the logical aspect of their subject. It is a pity that the first ambitious American work in this field should have so inadequate a foundation.

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An Introduction to Ethics for Training Colleges. G. A. Patterson. New York: The Macmillan Company. 1915. Pp. 248.

Teachers, and particularly students taking courses in teaching, have expressed to the reviewer their sense of a needed course in ethics. There seems in general no adequate course offered in institutions for the training of teachers.

This book is an attempt to provide a text-book for such a course. It wisely does not undertake the discussion of the difficult metaphysical problems underlying the moral life. But almost half of the book is devoted to the exposition of the psychological foundations of conduct. After the work of William James, A. F. Shand in his *Foundations of Character,* and William McDougall in his *Social Psychology,* to mention no others, no ethical treatise, especially for teachers, would be worth while which left out a study of the structure and development of moral consciousness.

The second part of the book discusses the usual topics of a treatise

[12] *Cf.* Russell, *Our Knowledge of the External World,* p. 150.

[13] Pp. 145–160, *Monist, ibid.,* pp. 345–361.

on ethics, always with a view to the special purpose of their relation to teaching.

In so brief a treatment of so broad a field doubtless the impression of superficiality is unavoidable. In the hands of a competent teacher, however, vital discussions of certain positions taken by the author would remove such an impression. An example of this is in the acceptance of the standard as reason. Just what does the author mean by reason? Is it the *a priori* faculty of the intuitionalists, or is it the process of reflection on the data of experience? The same problem arises, though in a different form, in the discussion of the nature of conscience in the first part of the treatise. A mastery of this central problem would seem to be of the greatest importance to any one who would undertake, not merely to impart information, but to mold character, which is, after all, what education fundamentally means.

In justice it should be said that the book is a well-arranged, clearly stated presentation of the subject from the point of view of the generally accepted moral philosophy, and well adapted, on the whole, to the special needs of the person preparing to teach.

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JOURNALS AND NEW BOOKS

MIND. April, 1916. *The Plot of Plato's Republic* (pp. 145–176): P. S. BURRELL. – Continues a detailed expository analysis of the contents of the *Republic,* maintaining the thesis that the dramatic form of the *Republic* is closely related to its subject-matter. Special attention is here given to Plato's account of the origin of society as set forth in Book II. *The Influence of Mathematical Conceptions on Berkeley's Philosophy* (pp. 177–192): G. A. JOHNSTON. – "By making use of comparatively recently discovered methods of calculation by signs and symbols he (Berkeley) sought to give an explanation of nature and its laws by means of the relation of sign and thing signified, and thus establish an Algebra of Nature; and he endeavored to develop an Algebra of Ethics by applying algebraic methods to the problems of morality." *Dreams as Psychical Explosions* (pp. 193–205): J. C. GREGORY. – A theory for the interpretation of the origin and nature of dreams to the effect that our expanded sense of duration in dreaming is due to the fact that most dreams occur at the moment of awakening at which time there is "an expanding effect of a sudden or explosive rise of interest." This theory is opposed to Bergson's relaxation or disinterestedness theory. *Retentiveness and Dreams* (pp. 206–222): HENRY RUTGERS MAR-

SHALL. – Distinguishes retentiveness from memory, and gives its physiological basis. Retentiveness does not mean storage of stimulative effects, but a new brain system as the result of readjustments. On the side of awareness there are sudden shiftings of the threshold of consciousness portraying retentiveness at different levels. Dreams represent sudden shiftings due to sudden arousings from sleep. *Discussion: The Nature and Geometry of Space:* J. E. TURNER. – A review of Mr. Broad's recent article: "Is our Space Euclidean?" *Critical Notes:* A. W. Benn, *The Greek Philosophers:* A. E. TAYLOR. A. J. Balfour, *Theism and Humanism* (Glasgow Gifford Lectures, 1914): J. S. MACKENZIE. John Dewey, *German Philosophy and Politics:* F. C. S. SCHILLER. D. C. Macintosh, *The Problem of Knowledge:* JOHN LAIRD. A. Mieli, *Le Scuole Ionica, Pythagorica ed Ileata:* P. E. B. JOURDAIN. H. Sturt, *The Principles of Understanding:* L. J. RUSSELL. *New Books. Philosophical Periodicals. Notes.*

MIND. July, 1916. *Laws of Thought* (pp. 289–307): J. S. MACKENZIE. – The fundamental laws of thought are to be regarded not psychologically nor as conditions of reality, but are to be interpreted as the implications involved in the exercise of thinking as, for example, having a concept implies the law of identity, judgment implies the law of contradiction, or inference implies the law of sufficient reason. *Berkeley's Realism* (pp. 308–328): J. LAIRD. – In view of current realistic interpretations of Berkeley, the attempt is made to show the exact relation of his philosophy to the neo-realism. Special attention is given to the points of difference, namely, Berkeley's theory of universals, the divergence with regard to the operations of the mind, and the differences between the Berkeleian phrase "in the mind" and the realistic doctrine of "independence." *The Plot of Plato's Republic* (pp. 329–364): P. S. BURRELL. – Seeks to show the essential unity of the *Republic,* and maintains that the plot develops without any break in continuity. Plato's procedure is to start with certain assumptions admitted as principles and to deduce what follows from these principles. Plato accepts the sophistical principle that every one seeks his own good, and this principle necessitates an account of the origin of society, the delineation of an ideal state, and the perversions of justice. *Discussion: The Egocentric Predicament.* HUGH A. REYBURN. – Disagrees with Professor Perry on his view that the ego-centric predicament, so far from being a basal argument for idealism, is a barren tautology. *Critical Notes:* G. Heymans, *Einführung in die Ethik auf Grundlage der Erfahrung:* A. E. TAYLOR. C. E. Vaughan, *The Political Writings of Jean Jacques Rousseau* (2 vols.): BERNARD BOSANQUET. *New Books. Philosophical Periodicals. Correspondence.*

Maudsley, Henry. Organic to Human: Psychological and Sociological. London and New York: Macmillan Company. 1916. Pp. viii + 386. $3.75.

Royce, Josiah. The Hope of the Great Community. New York: The Macmillan Company. 1916. Pp. 136. $1.00.

Wundt, Wilhelm. Elements of Folk Psychology. Tr. by Edward Leroy Schaub. London: George Allen and Unwin; New York: The Macmillan Company. 1916. Pp. xxiii + 532. $3.75.

Yerkes, Robert M.; Bridges, James W.; and Hardwick, Rose S. A Point Scale for Measuring Mental Ability. Monograph No. 1 of the Psychopathic Hospital of Boston. Baltimore: Warwick and York. 1915. Pp. 218. $1.25.

NOTES AND NEWS

THE TWENTY-FIFTH ANNUAL MEETING OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION

THE American Psychological Association held its twenty-fifth annual meeting at Teachers College, Columbia University, on Wednesday, Thursday, Friday, and Saturday, December 27 to 30. Attendance at the various sessions was larger than at any previous meeting, 141 being registered. Special features were the twenty-fifth anniversary programme, the anniversary banquet, and the exhibits of apparatus, materials, and literature.

On Thursday afternoon four papers were read as part of the anniversary programme. Professor Cattell spoke on "Our Psychological Organization and Research," Professor Jastrow on "Varieties of Psychological Experience," Professor Dewey on "The Need of a Social Psychology," and Professor Baird read a paper prepared by Professor Hall, who was prevented, by an accident, from attending the sessions. Thursday evening, at the banquet in the Hotel Marseilles, after-dinner speeches of a retrospective and reminiscent character were made by Professors Calkins, Ladd, and Sanford, and shorter speeches by Professors Jastrow, Thorndike, Watson, and Dr. Marshall. There was an attendance of 171 at the banquet, a record number.

As part of the general meeting of the Association for the Advancement of Science there had been prepared, in the gymnasium of Columbia University, a general exhibit of scientific materials, work, apparatus, etc., representing fifteen sciences. The psychological section was a prominent part of this exhibit and was a center of great interest. The Bureau of Educational Experiments, having its head-

quarters in the Educational Building, 70 Fifth Avenue, New York, had on display their collection of psychological and pedagogical tests and literature, presented in an interesting and accessible manner. The C. H. Stoelting Company had prepared their usual exhibit of psychological instruments and materials, and fifteen pieces of apparatus or teaching materials were exhibited by individual members of the Association.

The address of President Dodge occurred on Wednesday evening, the topic being "The Laws of Relative Fatigue." The annual business meeting of the Association followed the President's address, and after the business meeting an informal smoker was held in the psychological laboratory in Schermerhorn Hall. Detailed account of the business meeting will be found in the Proceedings of the Association and in the report of the retiring secretary, Professor Ogden. Professor Robert M. Yerkes, of Harvard University, was elected President of the Association for the ensuing year. Professors W. V. Bingham and H. L. Hollingworth were elected members of the Council for three years, succeeding Professors Franz and Whipple. Various committees reported progress, and appropriations were made for the purpose of facilitating their work. Of particular interest is the report of the Committee on the Academic Status of Psychology, prepared by Professor B. T. Baldwin. This committee presented its report in printed form, under the title "A Survey of Psychological Investigations with Reference to Differentiations between Psychological Experiments and Mental Tests." Copies of this report will be distributed to members of the Association.

Professor H. S. Langfeld was elected Secretary-Treasurer for the ensuing three years. An invitation from the President of the University of Michigan to hold the next annual meeting at Ann Arbor was accepted. Professor G. C. Basset was elected representative of the Association on the Council of the American Association for the Advancement of Science for the year 1917. Thirty-two new members were elected. Professors Baird and Angier and the Secretary are to constitute the programme committee for next year.

On Friday morning a joint session was held with Section L., A. A. A. S., and on Friday afternoon a joint session was held with Section H, at which the retiring Vice-president, Professor Lillien J. Martin, gave her address on "Personality as Revealed by the Content of Images."

Abstracts of the papers read at the regular sessions were printed before the sessions and distributed at the meetings. Inasmuch as these abstracts are to be published in the *Psychological Bulletin*, no attempt will be made here to summarize the contents of the various papers. The various fields of psychological interest were

very unevenly represented on the programme. On animal psychology there were but two papers, both dealing with definitions or general method. Physiological psychology was also represented by only two papers. On topics of abnormal psychology there were six papers. Three papers bore directly on problems of educational psychology, two particularly on apparatus, one on analytic psychology. General experimental psychology was represented by sixteen papers, varying widely in subject-matter. Almost as many papers, fourteen, were presented, bearing directly on mental tests, their validity, evaluation, elaboration, and significance. Aside from the papers on defectives and those on educational features, only one paper was presented in applied psychology.

H. L. HOLLINGWORTH.

COLUMBIA UNIVERSITY.

PROFESSOR R. S. WOODWORTH, of Columbia University, has completed the series of Jesup lectures of the American Museum of Natural History. The general topic was "Dynamic Psychology" and the subjects of the individual lectures were as follows: "The Modern Movement in Psychology," "The Problems and Methods of Psychology," "The Native Equipment of Man," "Acquired or Learned Equipment," "The Factor of Selection and Control," "The Factor of Originality," "Drive and Mechanism in Abnormal Behavior," and "Drive and Mechanism in Social Behavior."

DR. ERICH BECHER has been elected as successor to the late Professor Külpe at the University of Munich. Becher has been *ordinarius* at Münster since 1909, and among other writings has issued a volume on *"Gehirn und Seele."*

THE Johns Hopkins Press will shortly commence the publication of a series of translations and reprints with the general title of *Psychology Classics* under the editorship of Professor Dunlap.

W. H. NORCROSS, of Johns Hopkins University, has been appointed associate professor of psychology, philosophy, and education, in Dickinson College.

DR. HOWARD C. MARSH has been advanced from the grade of instructor to that of assistant professor of philosophy at the College of the City of New York.

AT the Ohio State University E. Leigh Mudge has been appointed instructor in psychology.